ONTARIO
DEPARTMENT OF
EDUCATION

General and Advanced Levels of Instruction in Grade 13

Chemistry

JANUARY, 1966

As recommended by the General and Advanced Committee which conducted part of the Grade 13 studies, the suggested outlines listed below have been prepared at the direction of the Minister of Education by the Curriculum Division with the assistance of university and secondary school personnel. The outlines are to be considered as working papers rather than definitive courses. It is expected that they would be subject to further development and change if it is decided to submit them to field testing. They are being distributed to the universities and to the secondary schools for evaluation.

GA. 31	Accountancy and Secretarial Studies
GA. 13	Art
GA. 17B	Biology
GA. 11	Classics
GA. 18	Chemistry
GA. 4	English
GA. 46	français
GA. 15A	French
GA. 17E	General Science
GA. 7	Geography
GA. 15B	German
GA. 9	History
GA. 12	Mathematics
GA. 16	Music
GA. 17C	Physics

BROAD SUGGESTED OUTLINES OF GENERAL AND ADVANCED COURSES IN CHEMISTRY

A. GENERAL LEVEL CHEMISTRY

1 Preamble

This course is designed to give those students who do not plan to major in science in post-secondary institutions of learning a general knowledge of chemistry, its applications, and its significance as it applies to everyday life. It should develop in the student a general chemical literacy and knowledge of his chemical environment.

2 Course outline

The committee recommends that the course of study should be centred around a few broad units of study such as those outlined below:

Unit 1 THE PERIODIC TABLE

A systematic study of the elements in the Periodic Table with reference to the similarities of properties in the various groups and the gradation of properties as one proceeds from one group to the next. Special emphasis should be given to the chemistry of the metallic elements. Reference should be made to some common compounds of the elements, their sources, uses, and the properties which make them useful. It is intended that this unit will include extensive laboratory work.

Unit 2 ORGANIC CHEMISTRY

A survey of simple organic compounds and their use in the production of such substances as gasoline, margarine, soaps, and simple food stuffs. The student should gain an elementary knowledge of such processes as oxidation, hydrogenation, esterification, and polymerization as they apply to organic compounds.

Reference should be made to polymers, drugs, etc., and their significance, complexity, and production in Canada.

Unit 3 RADIOCHEMISTRY

An elementary study of nuclear and radiochemistry and its application to areas such as medicine, dating of objects, tracing chemical reactions, and the development of power.

Unit 4 INDUSTRIAL CHEMISTRY

A survey of various industrial processes as they apply to the production of such common substances as structural metals, cement, fertilizers, sulphuric acid, explosives, and various household substances.

These processes may be discussed as they relate to substances studied in the previous units, and as far as possible from the standpoint of the energetics and kinetics of the fundamental processes involved.

3 Reference Texts

It is expected that the chemistry textbooks now used in Grade 13 would prove useful for the presentation of certain areas of this course. Additional books, such as the following, would also be of assistance:

Dull, C. E., Metcalfe, H. C. and Williams, J. E., *Modern Chemistry,* Holt, Reinhart and Winston, 1962.

Glasstone, S., *Sourcebook of Atomic Energy,* 2nd ed. Van Nostrand, 1958.

Numerous valuable paperbook publications are available.

B. ADVANCED LEVEL CHEMISTRY

1 Preamble

The Advanced Level Course in Chemistry is designed primarily for students planning to proceed to university to study one or more of the Physical Sciences. It will also be useful to those intending to study in the Life Sciences or in the Applied Sciences. Thus, the emphasis is on the principles and attitudes of the professional chemist. The students' "literacy" in science, as preparation for their ultimate role as citizens, will come naturally with deeper familiarity with the subject, but is not specifically included as an objective of this course.

The inevitable consequence of the continuously increasing body of chemical knowledge is that that part of chemistry which can reasonably be taught in an introductory course must from time to time be reconsidered in the light of its relevance and importance to the whole subject. The result of this sort of review is that some topics that have in the past been regarded as important have had to be removed or given diminished significance, and others brought into prominence. Among the latter, this course includes: much expanded attention to the structure of atoms, the energy associated with atomic and molecular events, the nature of bonding in molecules and crystals, the interpretation of redox-reactions in terms of electrochemical cells, a quantitative consideration of equilibrium, and the interpretation of reaction kinetics in terms of collision theory. As well as these changes in scientific content, the new course places some stress on the nature of scientific activity and scientific explanation and the use of models to explain and describe structure and reactions in chemistry.

The course given here is based on the Chemical Education Material Study (CHEM Study) Project in the United States. The textbook issued by this group, *Chemistry—An Experimental Science,* emphasizes in its title as well as its content the importance attached to laboratory work. From experimental work the student himself discovers the origin of chemical principles and the limitations and the interpretation of scientific measurements. The nature and number of the experiments will require the availability of laboratory facilities and the provision of time for their performance. In addition to the specifications of the CHEM Study course outline, teachers will be encouraged to extend and amplify the material where their individual interests make this possible.

2 Course Content

The committee suggests that the CHEM Study material could be considered as falling under the following five major headings:

Unit 1 ATOMIC STRUCTURE AND THE PERIODIC TABLE

The model of the atom studied in Grade 12 is extended to include chemical and physical evidence for the atomic theory and spectroscopic information regarding atomic and molecular dimensions.

A brief introduction to the chemical and physical properties of the elements in terms of their atomic structure provides an insight into the arrangement of elements within the periodic table.

Unit 2 ENERGETICS AND KINETICS OF CHEMICAL REACTIONS

The significance of the kinetic and potential energies of atoms and molecules is studied with a view to understanding the fundamental nature of chemical processes.

The concepts of chemical energy and the heat of chemical reactions, conservation of chemical energy, the concept of finite rates of chemical reactions, activation energy and catalysis, opposing reactions and dynamic equilibrium, the effect of internal and external conditions on the position of equilibrium, the equilibrium constant, are included as topics of study.

The application of these concepts to solubility, acid-base equilibria, and redox-reactions is also examined.

Unit 3 CHEMICAL BONDING AND MOLECULAR STRUCTURE

This unit includes a study of the structure of simple molecules and the forces which hold the atoms together; the nature of the chemical bonds as they apply to gaseous molecules, simple compounds, liquids and solids. The study encompasses covalent, ionic and metallic bonding.

Unit 4 THE CHEMISTRY OF SOME CARBON COMPOUNDS

A brief introduction is given to the chemistry of organic compounds. Topics studied include: structures of compounds, homologous series, functional groups, selected types of compounds such as amines, acids, unsaturated compounds, and the nature of some polymers.

Unit 5 THE CHEMISTRY OF SELECTED ELEMENTS

The basic principles developed in previous units are used to correlate the chemical and physical properties of elements such as the halogens, the alkaline earths, the elements of the third and fourth periods, the transition elements, the lanthanides, and the actinides.

C. ADVANCED LEVEL PHYSICAL SCIENCE

1 Introduction

As discussions progressed concerning the General and Advanced Level Program, meetings were held by the chairmen of the departments of physics and also by the chairmen of the departments of chemistry of the Ontario universities to assess the consequences of this program for university courses.

The views of the above two groups were conveyed to the General and Advanced Chemistry and Physics Committees. It was apparent that if the General and Advanced Level concept were introduced into Grade 13 both university groups would expect that Advanced Level Mathematics would be studied as a prerequisite to university studies in chemistry and physics. Furthermore, if the additional stipulation were made that two Advanced and two General Level courses were required for university entrance, then under this condition, both groups would favour a combined Physical Science course as the second Advanced Level course for students planning to continue studies in chemistry or physics at university. It was felt that the common areas of study in chemistry and physics would make such a course feasible. This proposal reflects the view which appears to be widely accepted, that all candidates for admission to science courses at university should follow essentially the same program in Grade 13.

In order to enable both the General and Advanced Level Physics and Chemistry Committees to proceed with their separate tasks, a sub-committee consisting of members of each of the aforementioned committees was formed to investigate the possibility of presenting a Physical Science course and to make a report to these committees.

The report of this sub-committee is presented below, followed by an account of the opinions expressed by both the General and Advanced Level Chemistry and Physics Committees.

2 Preamble

An integration of Physics and Chemistry into a single Physical Science course is based upon the mutual support the two separate sciences provide to each other in the pursuit of understanding of the fundamental structure of matter. In fact, the genesis of the basis of our present understanding, during the period from 1890 to 1930, was the result of a combined onslaught by physicists and chemists without concern for formal subdivisions. At the Grade 13 stage in a student's career, he could well be given ample opportunity to experience the interaction of the ideas contributed by both chemists and physicists. In particular, energy concepts developed from a physical point of view can provide a firmer foundation for the understanding of chemical reactions than would be possible without it. At the same time, the electronic basis of the periodic arrangement of the elements depends on a wealth of knowledge of chemical properties. When courses in chemistry and physics arrive at the details of atomic structure they are covering common ground.

The essence of the structure of this course is the provision of the understanding of fundamental concepts at each point as they are required to deepen the students' grasp of the next level of penetration into the details of the structure of matter. The topics that are listed in the outline below have been taken from *Physics,* by the Physical Science Study Committee, and from *Chemistry, an Experimental Science,* by the Chemical Education Materials Study. It is intended that, at least during the trial period, these two textbooks would form the basis of the course. As many as possible of the topics have been omitted to make it possible to handle the material in a single year. At the same time, enough must be retained to present a connected story of the investigation of the nature of matter.

During the trial period, at least, two teachers would likely be required for each class: one with a strong background in chemistry, and the other in physics. It is essential for the trial teachers to have a sufficient depth of understanding of these two sciences so that they can make day-to-day decisions about the presentation of the material and the directions of course development. During the trial period these teachers would have to determine how much of the material can be presented in a satisfactory manner in the available time. They would have to consult with others to consider which topics might be deleted if required. At the same time, the trial teachers should participate in training programs that have as their objective the preparation of teachers able to handle the physical science course by themselves.

3 Course Outline

The following course outline is based upon experimentation being conducted by certain science teachers in Oregon, U.S.A., in conjunction with the National Science Teachers' Association.

Unit 1 INTRODUCTION

1 Analysis of data
2 Time and its measurement
3 Space and its measurement
4 Motion along a straight-line path
5 Motion in space (vectors)
6 Molecules in the gas phase
7 Condensed phases of matter
8 Atomic structure and the periodic table

Unit 2 MECHANICS

1 Newton's law of motion
2 Motion at the earth's surface
3 Universal gravitation
4 Momentum and the conservation of momentum
5 Work and kinetic energy
6 Potential energy

Unit 3 HEAT AND ENERGY

1 Energy effects in chemical reactions
2 Heat and molecular motion

Unit 4 CHEMICAL REACTIONS

1 The rates of chemical reactions
2 Equilibrium in chemical reactions
3 Solubility equilibria
4 Aqueous acids and bases
5 Oxidation-reduction reactions
6 Chemical calculations

Unit 5 WAVE MOTIONS

1 Introduction to waves
2 Waves and light
3 Interference
4 Light waves

Unit 6 ELECTRICITY

1 Some qualitative facts about electricity
2 Coulomb's law and the elementary charge

Unit 7 ATOMS AND THE STRUCTURE OF MATTER

1 Exploring the atom
2 Photons and matter waves
3 Quantum systems and the structure of atoms
4 Electrons and the periodic table
5 Covalent bonds and molecular architecture
6 Bonding in solids and liquids

The following is a very tentative suggestion for a time schedule, to indicate the relative emphasis intended for each of the areas of study. Anything more precise or detailed than this would have to be developed by the trial teachers. The hour assignments are based on the six hours per week proposed by The General and Advanced Level Committee for Advanced Level subjects.

Section	*Number of hours*
A	36
B	36
C	8
D	36
E	14
F	8
G	36
	174

4 Comments of the Committees

(a) The General and Advanced Chemistry Committee

The view was expressed by at least one member of the Chemistry Committee that the approach of the chemist and the physicist are philosophically different, and hence these two subjects do not lend themselves to amalgamation at the Grade 13 level.

It was also argued by another member that the degree of sophistication in the teaching of both subjects at the Grade 13 level was such that the amalgamation of the two would be feasible and even desirable.

After much discussion concerning the advantages and disadvantages of a combined Physical Science course, the following conclusion was reached by a majority of the members:

"The evidence produced to date is not sufficient to justify the trend towards the blending of physics and chemistry into one course in secondary schools at this time.

"The problems involved, including the lack of teachers with adequate background in both physics and chemistry, the special laboratory arrangements required, the lack of sufficient background of the students in either physics or chemistry to enable them to appreciate the significance of the inter-relationship of the two areas of study, leads us to conclude that implementation of one course in Physical Science should be approached with extreme caution.

"We, therefore, recommend that there be separate courses in Chemistry and Physics in Grade 13."

(b) The General and Advanced Physics Committee

The members of the Physics Committee also stressed the necessity of approaching a Physical Science course with great care.

This committee was generally in favour of the proposed course outline in Physical Science if the conditions specified in the introduction were brought into effect.

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